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UNITED STATES
DEPARTMENT OF THE INTERIOR
Harold L. Ickes, Secretary

BUREAU OF MINES
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INFORMATION CIRCULAR

A STUDY OF EXPLOSIVES ACCIDENTS REPORTED TO THE NATIONAL SAFETY COMPETITION, 1925-35

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W. J. Fene

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UNITED STATES DEPARTMENT OF THE INTERIOR - BUREAU OF MINES

A STUDY OF EXPLOSIVES ACCIDENTS REPORTED TO THE NATIONAL SAFETY COMPETITION, 1925-35[1]

By W. J. Fene[2]

INTRODUCTION

A comprehensive study was made by S. P. Howell, explosives engineer, Federal Bureau of Mines, to determine the factors responsible for explosives accidents reported to the National Safety Competition during the 11-year period 1925 to 1935; 819 explosives-accident reports were reviewed by Mr. Howell, and pertinent information as to causes and influencing factors was tabulated therefrom; unfortunately, Mr. Howell died before he could embody his discussions and conclusions in a report. These tabulations are discussed, and in some instances recommendations are made for reducing the hazards connected with certain types of these accidents. These tabulations include all explosives accidents reported by anthracite, bituminous coal, and metal and nonmetallic mines, and quarries and open-cut mines entered in the competition. Many of the reports were incomplete and classification of certain factors in connection with the accidents was impossible.

NATIONAL SAFETY COMPETITION[3]

The National Safety Competition is conducted by the Bureau of Mines to arouse and maintain interest in safety in the mining and quarrying industries. This objective is attained through the efforts of the competing companies and their employees to win first place in the competition and thereupon receive national recognition for their achievement. Indirectly the purpose of the contest - the advancement of safety in the mining industry - is accomplished partly through studies by the Bureau of Mines of the accident reports that the competing companies furnish to enable the Bureau to compute the accident rates on which determination of the winners of the contest is based.

Since these annual contests were begun in 1925, the scope of the competition has been broadened materially as to number of plants participating and number of man-hours of exposure to accident hazards. Moreover, marked progress in the prevention of accidents has been achieved, as is indicated by an almost constant downward course in the accident-frequency rates for the contest group as a whole during the 11-year period. On the other hand, the accident-severity rates for the group showed an upward trend during the first part of the period and a downward trend during the last part.

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[1] The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from Bureau of Mines Information Circular 7038."

[2] Mining engineer, Bureau of Mines Safety Division, Pittsburgh, Pa.

[3] Adams, W. W., Lawrence, T. D., and White, D. R., The National Safety Competition of 1935: Rep. of Investigations 3308, Bureau of Mines, 1936, 20 pp.

The statistics that constitute the basis for determining the winning companies and the relative standing of all companies are prepared uniformly, without regard to the States in which the companies operate or to differences in classes of accidents covered by State laws relating to compensation for injuries resulting from industrial accidents.

Bronze trophies, known as "Sentinels of Safety", are provided by the Explosives Engineer Magazine to be awarded annually by the Bureau of Mines. Five trophies are presented each year, one to each company that establishes the best accident prevention record in one of the five classes - anthracite mining, bituminous-coal mining, metal mining, nonmetallic mineral mining other than coal, and quarrying or open-pit mining - into which all companies are divided. The trophies are awarded for one calendar year and are then transferred to the winners of the succeeding year's contest.

In determining the relative standing of the various companies enrolled in the competition, all mines and quarries are graded according to their accident-severity rates, that is, according to the number of days of disability of employees on account of accidents in proportion to the number of man-hours of work done by all employees at the plant. Reports of accidents and of man-hours worked are furnished to the Bureau of Mines by the companies. These reports are examined and classified carefully to insure uniform weighting of accidents according to the number of days of disability to be charged and to insure uniformity of methods of calculating the accident-severity rates for the various mines and quarries. When the relative standing of all plants has been determined, a summary of the records of the companies having the lowest accident-severity rates in their respective groups is sent to the members of a committee of awards for examination in accordance with the rules governing the safety contest.

It has been shown that participation in the National Safety Competition stimulates interest in accident prevention. Many companies have entered the competition with this idea in view. Other companies enter the competition because of good past accident records and expect to have a fair chance of winning the contest. Some companies have withdrawn from the contest before the end of the year because of an unfavorable accident record or the occurrence of a major disaster. As a rule, the larger companies enter the competition because, on the whole, they are likely to have better accident records than smaller companies due to greater activities and more effective organization in accident-prevention work. Companies that are eligible and are interested in accident prevention are urged to enroll in the contest.

Rules Governing the Award of Trophies

The rules governing the award of trophies in the National Safety Competition for 1938 were as follows:

1. FIVE TROPHIES AWARDED: The bronze trophy "Sentinels of Safety" will be awarded for the best safety record established in 1938 to the winning plant in each of five groups: (1) Anthracite mines, (2) bituminous-coal mines (includes lignite mines), (3) metal mines, (4) nonmetallic-mineral mines, (5) quarries or open-cut mines. This trophy will not be awarded outright but is to be retained by the winning company for a year and then transferred to the winner of the next year's contest. Honorable mention will be given to plants ranking second, third, fourth, and fifth in each group and to all plants going through the year without a lost-time accident. In addition to the trophy awarded to the company, each employee of the winning mine or quarry will receive a certificate of honor issued by the Bureau of Mines.

2. ELIGIBILITY: Underground mines employing 25 or more men underground (rule changed from 1932) and quarries or open-cut mines employing 25 or more men in the pit. To maintain eligibility for the trophy the plant must be active at least 150 days; quarries and open-cut mines having worked at least 30,000 man-hours inside the pit and underground mines at least 30,000 man-hours underground. Mines and quarries working a total of 30,000 man-hours are eligible for honorable mention, although they may not be eligible for the trophy because they do not employ 25 men underground or in the pit 150 days.

3. CONTEST PERIOD: January 1 to December 31, 1938.

4. SCOPE OF CONTEST: The contest covers lost-time accidents and man-hours worked underground or in the quarry or pit, also at surface shops and yards, including crushing and screening plants at the mine or quarry or pit. The contest does NOT cover smelting, ore-dressing, cement mills, limekilns, or stone dressing, nor does it cover breakers at anthracite mines. (See rule 5.) Office employees, also, are not included.

5. SEPARATE ENROLLMENT OF EACH PLANT: A separate enrollment application should be filed for each mine or quarry. A company may select one or more of its plants for entry in the contest. (For purposes of the contest, an underground anthracite mine is defined as an underground excavation and development - a single operating unit - with shafts, slopes, drifts, or tunnels for the extraction of anthracite coal; it includes all underground and surface operations under the mining company's control except those at the breaker, power plant, and boiler house and employees of independent contractors, not under the control of the local officials of the

mining company. An anthracite stripping operation is also defined as above except that the coal is mined from an open excavation instead of underground.)

6. THE WINNERS: The winner in each of the above five groups will be the mine or quarry having the lowest accident-severity rate, that is, the smallest loss of time from all fatal, permanent, and lost-time injuries per 1,000 man-hours worked. Should two or more plants have no accidents causing loss of time, the trophy shall be awarded as stated in Rule 9.

7. REPORTS REQUIRED:

a. Accident reports: Competing companies agree to send to the Bureau of Mines a separate and full report of each lost-time accident. (A lost-time accident is defined as one that causes disability beyond the remainder of the day on which the accident occurred. This also covers injuries that do not incapacitate an employee for work until some time in the future; for example, as the result of infection.) All fractures or permanent injuries should be reported even if no time is lost; also, all temporary injuries that prevent an employee from performing his regular duties, even though during convalescence the injured employee returns to lighter work. Companies may use accident report forms supplied by the Bureau of Mines or they may send the Bureau a copy of their reports to the State Commission or their insurance carriers. Each accident report should show date of injury, date that disability begins, date of ability to resume work, and number of calendar days lost. In counting the number of calendar days lost, the day of injury should not be counted, nor should the day of ability to resume work be counted unless disability existed on part of that day, in which case the fact should be stated on the company's report of the accident. The plant's enrollment or entry number should be shown on each accident report.

b. Exposure reports: The number of man-hours of employment or exposure should be reported on forms supplied by the Bureau of Mines; this includes man-hours of exposure of service or maintenance-men or days when mine or quarry was not producing.

c. Completeness and accuracy: Company reports to be summarized by the Bureau of Mines at the close of the year and that summary mailed to company, the company to certify same as to completeness and accuracy and return same to the Bureau of Mines.

8. WHEN TO SEND REPORTS: Accident reports should be mailed to the Bureau of Mines, Washington, D. C., when the injured employee returns to work or when disability ceases. They may, if desired, be mailed to the Bureau at the close of each month. However, all

reports should be mailed before January 31, 1939, so that the winners of the contest may be announced early in the year. Company will estimate number of days of disability if disability is expected to continue beyond January 31, 1939. Reports of man-hours worked should be mailed monthly or whenever convenient to the reporting company.

9. METHODS OF RATING: Mines and quarries will be rated according to their accident-severity rates, that is, according to the number of calendar days of personal disability from injuries per 1,000 man-hours worked by all employees (except office workers) at the mine or quarry and at the surface plant connected with the mine or quarry. Deaths and permanent disabilities are weighted according to the scale shown in table 1. Temporary disabilities are weighted according to actual calendar days of disability, including Sundays, holidays, and days on which the plant was idle, if the injured employee was physically unable to work on those days. The severity rate is obtained by dividing the total number of days of disability from accidents by the total number of man-hours worked and multiplying the quotient by 1,000. If two or more mines or quarries have no lost-time accidents, the award shall go to the plant having the largest number of man-hours of exposure during the year.

10. COMMITTEE OF AWARD: The winning companies are selected by a Committee of Award composed of seven members, identified with the mineral industry but not connected with the Bureau of Mines.

11. MISCELLANEOUS: The above rules shall govern the contest during 1938. The rules for subsequent years may be revised as experience shows to be advisable.

12. RECORDS CONFIDENTIAL: Records will not be published in such a way as to reveal the identity of an individual plant, unless the plant wins the trophy or is awarded honorable mention, in which case the record will be published as a credit to the company, except that outstanding safety records may be published for plants operating two or more years without lost-time accidents or with unusually low accident rates.

13. DEFINITION OF ACCIDENT RATES:

Frequency rate means the number of all injuries (fatal, permanent, and temporary lost-time injuries) per million man-hours of exposure.

Severity rate means the number of days of disability resulting from all injuries (fatal, permanent, and temporary lost-time injuries) per thousand man-hours of exposure.

TABLE 1. - Scale of time losses for weighting deaths and permanent injuries so as to show severity of injuries

Nature of injury[1]	Degree of disability in percent of permanent total disability	Days lost
Death	100	6,000
Permanent total disability	100	6,000
Arm above elbow, dismemberment or loss of use of	75	4,500
Arm at or below elbow, dismemberment or loss of use of	60	3,600
Hand, dismemberment or loss of use of	50	3,000
Thumb, dismemberment or loss of use of	10	600
Any 1 finger, dismemberment or loss of use of	5	300
2 fingers, dismemberment or loss of use of	12-1/2	750
3 fingers, dismemberment or loss of use of	20	1,200
4 fingers, dismemberment or loss of use of	30	1,800
Thumb and 1 finger, dismemberment or loss of use of	20	1,200
Thumb and 2 fingers, dismemberment or loss of use of	25	1,500
Thumb and 3 fingers, dismemberment or loss of use of	33-1/3	2,000
Thumb and 4 fingers, dismemberment or loss of use of	40	2,400
Leg above knee, dismemberment or loss of use of	75	4,500
Leg at or below knee, dismemberment or loss of use of	50	3,000
Foot, dismemberment or loss of use of	40	2,400
Great toe, or any 2 or more toes, dismemberment or loss of use of	5	300
1 toe, other than great toe, dismemberment or loss of use of	0	---
1 eye, loss of sight	30	1,800
Both eyes, loss of sight	100	6,000
1 ear, loss of hearing	10	600
Both ears, loss of hearing	50	3,000

[1] Dismemberment means severance of any part of the bone.

Temporary disabilities are weighted according to the actual number of calendar days of disability, including Sundays and holidays, as stated in Rule 9. Hernia is classed as a temporary disability to be charged with the actual number of calendar days during which the employee was unable to work.

EXPLOSIVES ACCIDENTS

The dangerous nature of explosives makes them a potential hazard wherever they are used, but they are likely to have maximum harmfulness under the conditions inherent in mining. The ease with which explosives can be detonated and the suddenness and violence with which they detonate require great care in their handling and use if severe accidents are to be avoided. Since about the beginning of this century, and more particularly since 1910, a campaign has been waged by various agencies to educate users of explosives in their dangers and in their proper handling and use, and this campaign has been especially active in connection with mining. Probably 95 percent of explosives accidents can be attributed to misjudgment, carelessness, and negligence or chance taking. These safety educational campaigns have resulted in fewer explosives accidents, particularly coal-mine disasters caused by explosives; however, accidents due to explosives continue to occur far to frequently, and it is evident that much is yet to be done in controlling the various factors that contribute to such accidents, the human factor being perhaps the most important to reach effectively.

Normally, about 10 percent of all fatalities in coal mining are caused by explosives accidents (excluding gas and dust explosions caused by explosives); about 12 percent of all fatalities in metal mining are so caused. A study of the accident records of the companies entered in the National Safety Competition from 1925 to 1935, inclusive, shows that in bituminous-coal mining 3.3 percent of the fatalities and 0.84 percent of the nonfatal injuries were caused by explosives; in anthracite mining, 7.1 percent of the fatal and 1.1 percent of the nonfatal accidents were caused by explosives. Records of metal-mining companies entered in the competition show that 16.8 percent of the fatal and 1.6 percent of the nonfatal accidents were caused by explosives. The frequency of fatal explosives accidents in quarries and open-cut mines is also high, accounting for 17.6 percent of the fatalities from all causes. In nonmetallic mines explosives were responsible for 4.3 percent of all fatal and 1.3 percent of all nonfatal accidents. The severity of explosives accidents is likely to be much greater than that of other types of accidents, a single accident often resulting in the death of two or more men.

Record of Explosives Accidents

Table 2 gives the record of explosives accidents reported by companies entered in the National Safety Competition from 1925 to 1935, inclusive. Quarrying and open-cut mining involved the greatest number of fatal accidents (23), probably because more plants from this group were entered in the competition than from the other groups. Anthracite and metal mines each had 20 fatal accidents during the period, compared to 14 fatal accidents for bituminous-coal mines. Nonmetallic mines reported one fatality. Of a total of 819 explosives accidents reported, 9.52 percent resulted fatally; 1.1 percent resulted in permanent total injuries; 7.57 percent resulted in permanent partial injuries; and 81.81 percent resulted in temporary injuries.

TABLE 2. - Record of explosives accidents, 1925 to 1935, inclusive

F = Fatal. PP = Permanent partial.
PT = Permanent total. T = Temporary

	Anthracite				Bituminous				Metal				Nonmetallic				Quarry and open-cut				Total			
Year	F	PT	PP	TEMP	F	PT	PP	TEMP	F	PT	PP	TEMP	F	PT	PP	TEMP	F	PT	PP	TEMP	F	PT	PP	TEMP
1925	1	-	-	6	-	-	3	18	1	-	4	20	-	-	1	2	4	-	1	29	6	-	9	75
1926	2	-	3	21	-	-	1	15	3	-	1	31	1	-	-	6	6	1	3	51	12	1	8	124
1927	3	-	2	20	-	-	1	8	3	-	4	16	-	-	-	-	4	-	1	19	10	-	8	63
1928	2	-	-	20	-	-	1	15	5	-	2	9	-	-	-	3	1	-	-	10	8	-	3	57
1929	2	-	4	28	-	-	2	11	-	-	4	8	-	-	1	-	2	-	1	18	4	-	12	65
1930	2	2	1	33	3	-	1	12	2	1	-	3	-	-	-	-	5	-	3	18	12	3	5	66
1931	2	-	1	7	-	-	3	22	1	1	2	3	-	-	-	1	-	-	-	11	3	1	6	44
1932	2	-	1	11	2	-	-	21	2	-	1	8	-	-	-	1	1	-	-	2	7	-	2	43
1933	-	-	1	23	2	1	-	14	1	-	-	6	-	-	-	-	-	1	-	2	3	2	1	45
1934	1	1	3	20	2	-	-	19	2	1	1	4	-	-	-	-	-	-	-	4	5	2	4	47
1935	3	-	1	20	5	-	1	18	-	-	-	-	-	-	-	1	-	-	2	2	8	-	4	41
Total	20	3	17	209	14	1	13	173	20	3	19	108	1	-	2	14	23	2	11	166	78	9	62	670

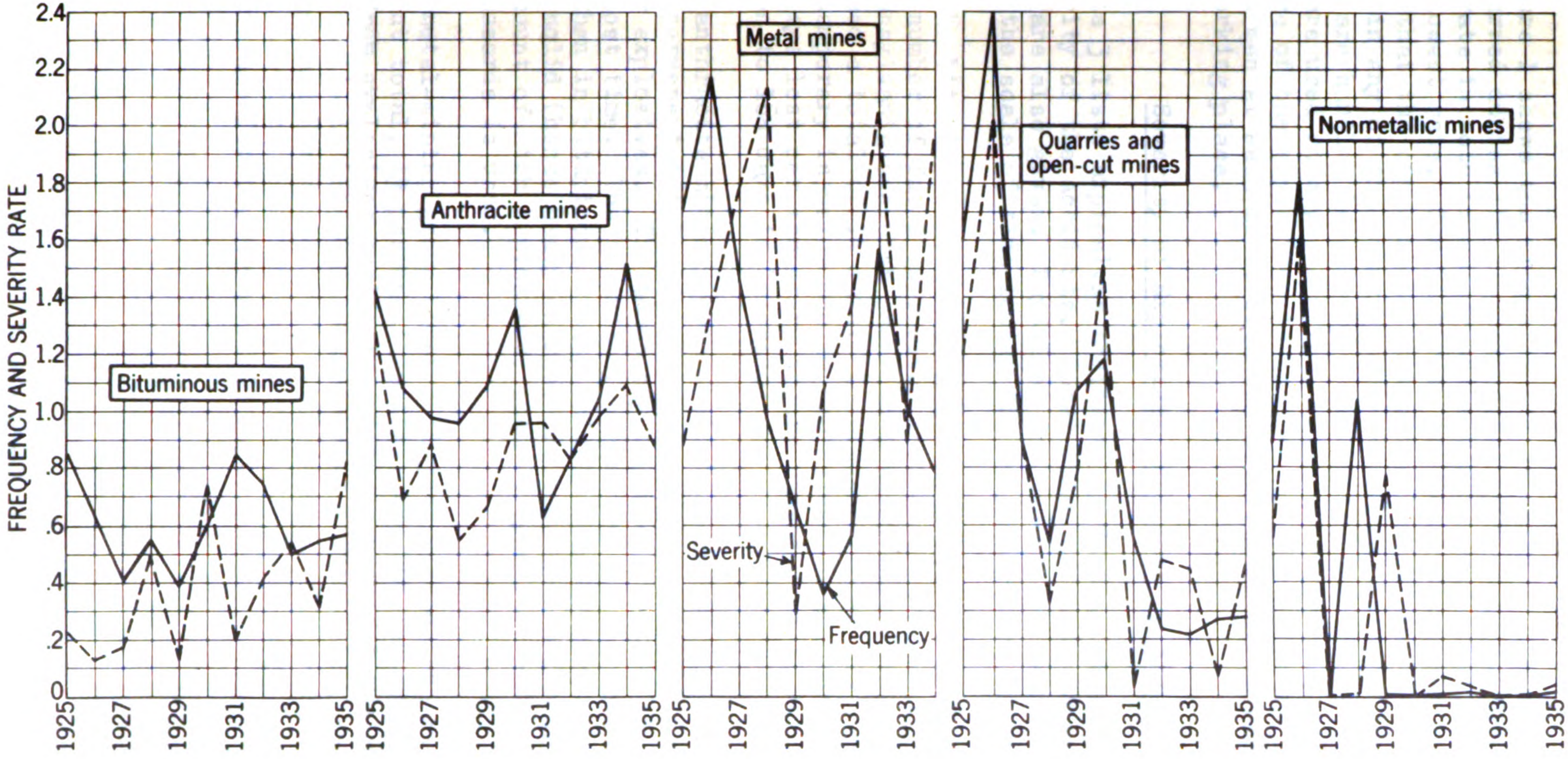

Figure 1.—Frequency and severity of explosives accidents.

Frequency and Severity of Explosives Accidents

Figure 1 shows the frequency and severity of the explosives accidents that occurred during the 11-year period 1925 to 1935. Metal mining had the highest rate in both frequency and severity, while bituminous-coal mines had the lowest rate. The high rate for metal mines may be explained by the fact that the exposure to explosives hazards is greater in metal mining than in any of the other groups; moreover, in metal mining the explosives are handled largely by individuals, and usually much heavier charges are used at any one place, while in bituminous-coal mining a large percentage of the explosives is handled by only a few relatively well-qualified men at each mine, with the quantity of explosive much less in any single working place.

Severity of Explosives Accidents by States

Table 3 lists explosives accidents by States, classified according to the severity of the accidents. Total days lost and average days lost per accident are also given. Days lost for deaths and permanent injuries are based on the scale of time losses for weighting such injuries. (See table 1.)

In the bituminous-coal mining group, Kentucky and Wyoming had the greatest number of fatal explosives accidents (3 each) during this period, while Pennsylvania and Utah each had 2 fatal accidents. This group experienced a total of 14 fatal, 1 permanent total, 13 permanent partial, and 173 temporary injuries due to explosives during the period. The average days lost per temporary injury ranged from 12 days in Alabama and Washington to 168 days in Colorado.

The anthracite mining group - all in Pennsylvania - experienced 20 fatal, 3 permanent total, 17 permanent partial, and 209 temporary injuries caused by explosives. The temporary injuries resulted in an average of 30 days lost time. The hazards of explosives in anthracite mines are greater than in bituminous mines, chiefly because more of the coal is shot from the solid (hence heavy charges are required) and a greater proportional amount of high explosives, such as dynamite, with their inherently greater hazards is used.

The metal-mining group (over a 10-year period) experienced 20 fatal, 3 permanent total, 19 permanent partial, and 108 temporary injuries resulting from explosives accidents. Arizona reported the greatest number of fatal accidents (6); Oklahoma reported 3 fatalities, and Michigan, New Jersey, and New Mexico 2 fatalities each. The average days lost per temporary accident ranged from 1 day in New York to 78 days in Michigan, with an average for the group of 35 days.

TABLE 3. - Explosives accidents, by States, classified according to severity, 1925 to 1935.
F = Total. PT = Permanent total. PP = Permanent partial. T = Temporary.

State	1925				1926				1927				1928				1929				1930				1931				1932			
	F	PT	PP	T	F	PT	PP	T	F	PT	PP	T	F	PT	PP	T	F	PT	PP	T	F	PT	PP	T	F	PT	PP	T	F	PT	PP	T
Bituminous-coal mines:																																
Alabama	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	4	-	-	-	-	-	-	3	1	-	-	-	-
Colorado	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-	-	-
Illinois	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	3
Kentucky	-	-	-	-	-	-	-	3	-	-	-	2	-	-	1	-	-	-	1	3	-	-	1	-	-	-	-	-	-	-	-	-
Maryland	-	-	2	1	-	-	-	3	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
North Dakota.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Ohio	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	-	-	-	10	1	-	-	7
Pennsylvania.	-	-	-	-	-	-	-	1	-	-	1	1	-	-	-	9	-	-	-	2	-	-	-	2	-	-	-	6	-	-	-	9
Tennessee ...	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Utah	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	2	-	-	-	-	-	-	-	-
Virginia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1
Washington ..	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
West Virginia	-	-	-	8	-	-	1	7	-	-	-	-	-	-	-	4	-	-	1	1	-	-	-	-	-	-	-	4	-	-	-	-
Wyoming	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	-	-	3	18	-	-	1	15	-	-	1	8	-	-	1	15	-	-	2	11	3	-	1	12	-	-	3	22	2	-	-	21
Anthracite mines:																																
Pennsylvania.	1	-	-	6	2	-	3	21	3	-	2	20	2	-	-	20	2	-	4	28	2	2	1	33	2	-	1	7	2	-	1	11
Metal mines:																																
Arizona	-	-	1	5	-	-	-	-	2	-	2	5	2	-	-	2	-	-	2	2	2	-	-	-	-	-	1	1	-	-	-	-
Colorado	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	3	-	-	-	1	-	-	-	1	-	-	-	1
Kansas	-	-	2	1	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Michigan	-	-	-	1	-	-	1	2	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	1	1	-	1	7
Minnesota ...	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Missouri	1	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
New Jersey ..	-	-	-	1	-	-	-	2	-	-	-	-	2	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
New Mexico ..	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
New York	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Oklahoma	-	-	-	2	2	-	-	2	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
South Dakota.	-	-	1	4	1	-	-	11	-	-	-	4	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tennessee ...	-	-	-	-	-	-	-	2	-	-	1	3	-	-	-	1	-	-	-	1	-	-	-	-	-	-	-	-	1	-	-	-
Texas.......	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Utah	-	-	-	-	-	-	-	12	-	-	-	2	1	-	-	1	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
Wisconsin ...	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Total	1	-	4	20	3	-	1	31	3	-	4	16	5	-	2	9	-	-	4	8	2	1	-	3	1	1	2	3	2	-	1	8

TABLE 3. - Explosives accidents, by States, classified according to severity, 1925 to 1935. (Continued)
F = Total. PT = Permanent total. PP = Permanent partial. T = Temporary.

State	1933				1934				1935				Total				Total days lost				Average days lost per accident			
	F	PT	PP	T	F	PT	PP	T	F	PT	PP	T	F	PT	PP	T	F	PT	PP	T	F	PT	PP	T
Bituminous-coal mines:																								
Alabama	-	-	-	2	-	-	-	1	-	-	-	-	-	-	3	9	-	-	5,160	105	-	-	1,720	12
Colorado	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	4	6,000	-	-	674	6,000	-	-	168
Illinois	-	-	-	1	-	-	-	1	-	-	-	1	1	-	-	10	6,000	-	-	473	6,000	-	-	47
Kentucky	1	1	-	-	2	-	-	3	-	-	-	1	3	1	3	12	18,000	6,000	4,250	440	6,000	6,000	1,417	37
Maryland	-	-	-	-	-	-	-	-	-	-	-	1	-	-	2	7	-	-	5,010	121	-	-	2,505	17
North Dakota ..	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	2	-	-	-	44	-	-	-	22
Ohio	-	-	-	1	-	-	-	6	-	-	-	3	1	-	-	34	6,000	-	-	939	6,000	-	-	28
Pennsylvania ..	1	-	-	9	-	-	-	4	1	-	-	7	2	-	1	50	12,000	-	3,000	2,287	6,000	-	3,000	46
Tennessee	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	2	-	-	-	44	-	-	-	22
Utah	-	-	-	-	-	-	-	-	-	-	-	-	2	-	1	3	12,000	-	300	126	6,000	-	300	42
Virginia	-	-	-	1	-	-	-	1	-	-	-	2	-	-	-	6	-	-	-	192	-	-	-	32
Washington	-	-	-	-	-	-	-	-	1	-	-	-	1	-	-	5	6,000	-	-	61	6,000	-	-	12
West Virginia .	-	-	-	-	-	-	-	1	-	-	-	1	-	-	2	26	-	-	4,800	839	-	-	2,400	32
Wyoming	-	-	-	-	-	-	-	1	3	-	1	1	3	-	1	3	18,000	-	4,500	139	6,000	-	4,500	46
Total	2	1	-	14	2	-	-	19	5	-	1	18	14	1	13	173	84,000	6,000	27,020	6,484	6,000	6,000	2,078	37
Anthracite mines:																								
Pennsylvania...	-	-	1	23	1	1	3	20	3	-	1	20	20	3	17	209	120,000	18,000	31,800	6,306	6,000	6,000	1,829	30
Metal mines:																								
Arizona	-	-	-	-	-	-	-	-					6	-	6	15	36,000	-	11,455	464	6,000	-	1,909	31
Colorado	-	-	-	6	-	-	-	-					-	-	1	12	-	-	800	196	-	-	800	16
Kansas	-	-	-	-	-	-	-	-					-	-	2	3	-	-	5,100	22	-	-	2,550	7
Michigan	-	-	-	-	-	-	1	-					2	1	3	12	12,000	6,000	5,400	933	6,000	6,000	1,800	78
Minnesota	-	-	-	-	-	-	-	-					-	-	2	-	-	-	3,600	-	-	-	1,800	-
Missouri	-	-	-	-	-	-	-	-					1	1	-	6	6,000	6,000	-	352	6,000	6,000	-	59
New Jersey	-	-	-	-	-	-	-	-					2	-	1	4	12,000	-	3,000	363	6,000	-	3,000	91
New Mexico	-	-	-	-	2	-	-	4					2	-	-	4	12,000	-	-	113	6,000	-	-	38
New York	1	-	-	-	-	-	-	-					1	-	-	1	6,000	-	-	1	6,000	-	-	1
Oklahoma	-	-	-	-	-	-	-	-					3	-	1	4	18,000	-	1,800	216	6,000	-	1,800	54
South Dakota ..	-	-	-	-	-	-	-	-					1	-	1	23	6,000	-	300	590	6,000	-	300	26
Tennessee	-	-	-	-	-	1	-	-					1	1	1	7	6,000	6,000	1,200	227	6,000	6,000	1,200	32
Texas..........	-	-	-	-	-	-	-	-					-	-	-	1	-	-	-	32	-	-	-	32
Utah	-	-	-	-	-	-	-	-					1	-	1	15	6,000	-	3,000	191	6,000	-	3,000	13
Wisconsin	-	-	-	-	-	-	-	-					-	-	-	1	-	-	-	45	-	-	-	45
Total	1	-	-	6	2	1	1	4					20	3	19	108	120,000	18,000	35,655	3,745	6,000	6,000	1,876	35

TABLE 3. - Explosives accidents, by States, classified according to severity, 1925 to 1935. (Continued)
F = Total. PT = Permanent total. PP = Permanent partial. T = Temporary.

	1925				1926				1927				1928				1929				1930				1931				1932			
State	F	PT	PP	T	F	PT	PP	T	F	PT	PP	T	F	PT	PP	T	F	PT	PP	T	F	PT	PP	T	F	PT	PP	T	F	PT	PP	T
Quarry and open-cut mining:																																
California ..	4	-	-	-	-	-	-	-	-	-	-	1	-	-	-	2	-	-	-	1	-	-	-	1	-	-	-	-	-	-	-	-
Colorado	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Connecticut .	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Florida	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
Illinois	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	2	-	-	-	1
Indiana	-	-	-	-	-	-	-	1	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-
Kansas	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
Kentucky	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	5	4	-	2	10	-	-	-	1	-	-	-	-
Maryland	-	-	-	1	-	-	-	2	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Maine	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
Minnesota ...	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Missouri	-	-	-	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
Montana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
New Jersey ..	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-	-	-	-	-	-	-	-
New York	-	-	-	-	-	-	1	1	2	-	-	3	-	-	-	-	-	-	-	2	-	-	-	1	-	-	-	-	-	-	-	-
Ohio	-	-	-	1	-	-	-	1	-	-	-	1	-	-	-	-	-	-	-	1	-	-	-	1	-	-	-	-	-	-	-	-
Oklahoma	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Pennsylvania.	-	-	-	6	2	1	1	17	2	-	-	4	1	-	-	2	-	-	-	3	-	-	-	1	-	-	-	-	-	-	-	1
Tennessee ...	-	-	-	1	-	-	-	1	-	-	-	1	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Texas	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Utah	-	-	1	18	2	-	-	24	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	1	-	-	-
Virginia	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Washington ..	-	-	-	-	1	-	-	2	-	-	-	-	-	-	-	1	2	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-
Wisconsin ...	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
West Virginia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Total	4	-	1	29	6	1	3	51	4	-	1	19	1	-	-	10	2	-	1	18	5	-	3	18	-	-	-	11	1	-	-	2
Nonmetallic mining:																																
Illinois	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Louisiana ...	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
Michigan	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Missouri	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Nebraska	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
New York	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ohio	-	-	-	-	1	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pennsylvania.	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
West Virginia	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	-	-	1	2	1	-	-	6	-	-	-	-	-	-	-	3	-	-	1	-	-	-	-	-	-	-	-	1	-	-	-	1

TABLE 3. - Explosives accidents, by States, classified according to severity, 1925 to 1935. (Continued)

F = Total. PT = Permanent total. PP = Permanent partial. T = Temporary.

State	1933				1934				1935				Total				Total days lost				Average days lost per accident			
	F	PT	PP	T	F	PT	PP	T	F	PT	PP	T	F	PT	PP	T	F	PT	PP	T	F	PT	PP	T
Quarry and open-cut mining:																								
California ..	-	-	-	-	-	-	-	1	-	-	-	-	4	-	-	6	24,000	-	-	272	6,000	-	-	48
Colorado ...	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-	-	-	1
Connecticut	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	20	-	-	-	20
Florida	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	14	-	-	-	14
Illinois ...	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	6	-	-	4,500	318	-	-	4,500	53
Indiana	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1	5	-	-	1,800	204	-	-	1,800	41
Kansas	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	13	-	-	-	13
Kentucky ...	-	-	-	-	-	-	-	-	-	-	-	-	4	-	2	17	24,000	-	1,800	364	6,000	-	900	21
Maryland ...	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	99	-	-	-	25
Maine	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	6,000	-	-	-	6,000	-	-	-
Minnesota ..	-	-	-	-	-	-	-	-	-	-	1	-	-	-	2	1	-	-	3,600	53	-	-	1,800	53
Missouri ...	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	158	-	-	-	53
Montana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	800	56	-	-	800	56
New Jersey .	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	279	-	-	-	139
New York ...	-	1	-	1	-	-	-	-	-	-	-	-	2	1	1	8	12,000	6,000	4,500	425	6,000	6,000	4,500	53
Ohio	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-	-	56	-	-	-	11
Oklahoma ...	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	800	-	-	-	800	-
Pennsylvania	-	-	-	-	-	-	-	1	-	-	-	-	5	1	1	35	36,000	6,000	-	2,914	6,000	6,000	-	83
Tennessee ..	-	-	-	-	-	-	-	1	-	-	-	2	-	-	-	8	-	-	-	513	-	-	-	64
Texas	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	2	-	-	-	23	-	-	-	12
Utah	-	-	-	-	-	-	-	-	-	-	-	-	3	-	1	49	18,000	-	1,200	680	6,000	-	1,200	14
Virginia ...	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	6,000	-	-	56	6,000	-	-	56
Washington .	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	7	18,000	-	-	574	6,000	-	-	82
Wisconsin ..	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	10	-	-	-	10
West Virginia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	54	-	-	-	54
Total	-	1	-	2	-	-	-	4	-	-	2	2	23	2	11	166	144,000	12,000	19,000	7,156	6,000	6,000	1,900	43
Nonmetallic mining:																								
Illinois ...	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	12	-	-	-	6
Louisiana ..	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	16	-	-	-	16
Michigan ...	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	38	-	-	-	19
Missouri ...	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	4	-	-	-	4
Nebraska ...	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	300	-	-	-	300	-
New York ...	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	4	-	-	-	166	-	-	-	41
Ohio	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	3	6,000	-	-	181	6,000	-	-	60
Pennsylvania	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	7	-	-	-	7
West Virginia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1,800	-	-	-	1,800	-
Total	-	-	-	-	-	-	-	-	-	-	-	1	1	-	2	14	6,000	-	2,100	424	6,000	-	1,050	30

The quarry and open-cut mines experienced 23 fatal, 2 permanent total, 11 permanent partial, and 136 temporary injuries from explosives accidents during the 11-year period. Pennsylvania had 6 fatalities, California and Kentucky 4 each, and Utah and Washington 3 each. The average days lost per temporary injury ranged from 1 day in Colorado to 139 days in New Jersey, with an average of 43 days per temporary injury for the group.

The nonmetallic mining group experienced 1 fatal, 2 permanent partial, and 14 temporary injuries due to explosives. It is observed that in 3 of the 11 years this group reported only one explosives accident per year and reported none in two of the 11 years. The average time lost for temporary injuries ranged from 6 days in Illinois to 60 days in Ohio.

The five groups experienced a total of 667,670 days lost time from explosives accidents during the 11-year period.

In considering the severity of explosives accidents, it was found that 74 (23 percent) of those reported involved two or more men and that 47 men received fatal and 144 nonfatal injuries. The severity of quarry and open-cut mine explosives accidents appears to be the greatest. In 16 of these multiple-injury accidents in this group, 16 men were killed and 38 injured. The ratio for metal mining is also high compared with that of other groups, probably because larger charges of explosives are used than in coal or nonmetallic mines. These multiple accidents are given in the following table:

Multiple-injury accidents

	Anthracite	Bituminous coal	Metal	Quarries and open-cut	Nonmetallic	Total
Number of multiple accidents	27	15	14	16	2	74
Number killed	11	8	12	16	-	47
Number injured.......	49	26	27	38	4	144
Number accidents causing fatalities	10	4	9	7	-	30

Causes of Explosives Accidents

In many explosives accidents it is most difficult to determine definitely the cause, as the evidence of the origin is destroyed by the blast and frequently those involved have been killed. Even where there are survivors of the accidents, they are often of little help in determining the cause, as the accident occurs so suddenly they cannot tell what happened or prefer not to divulge whatever information they have.

Probably the greatest cause of explosives accidents - one not ordinarily listed in reports of accidents - is carelessness, misjudgment, or chance-taking in handling and using explosives; this cause is inexcusable and can be almost eliminated by proper education and supervision.

Flying material from blast. - By referring to table 4, it can be seen that of the explosives accidents reported in the competition, being hit by flying or blasted material caused the largest percentage of all injuries (38.6 percent) from explosives. This hazard was more prevalent in quarrying and open-cut mining and was responsible for 115 (36 percent) of the accidents from explosives. Bituminous-coal mines had 81 such accidents; anthracite, 76; metal mines, 44; and nonmetallic mines, 1. If blasting in underground mines were done at the end of the shift on an off shift rather than during the working shift, most of the blasting accidents of this type would be avoided. Due to lack of natural shelter in quarries and open-cut mines, the hazard from flying material from blasts is much greater than in underground mines; however, proper protection from this hazard can be obtained by the erection of barriers and by seeing that everyone not engaged in the blasting operation is "in the clear."

Some of the factors (virtually all human and subject to control) that cause injuries from flying blasted material are:

1. Short fusing.
2. Staying too long at face when spitting.
3. Losing light while spitting fuse.
4. Unguarded shots and improper or no warning signals.
5. Returning too soon after shot has been fired or after misfire.
6. Shot breaking through rib or face.
7. Firing cable too short to permit proper shelter.

Premature shots. - Premature shots were the second greatest cause of injuries, being responsible for a total of 207 injuries (25.3 percent of all explosives accidents). Quarries and open-cut mining experienced 57 such injuries (27 percent of the total), while bituminous mines had 53, anthracite mines 52, metal mines 38, and nonmetallic mines 8.

Some of the factors that produce premature shots are:

1. Short fusing.

2. Electric firing due to (a) detonator legs not shorted; (b) premature firing by power other than from battery or magneto; (c) stray currents; unsafe types of shot-firing batteries; unsafe use of electric batteries or shooting wires.

3. Loading hole due to impact of tamping rod or friction of metal tamping rod.

Asphyxiation from noxious gas. - Asphyxiation from fumes of explosives was responsible for 91 (about 11 percent) of all fatal and nonfatal injuries. Sixty of these cases occurred in anthracite mines, 19 in metal mines, 11 in bituminous mines, and 1 in nonmetallic mines. The prevalence of this type of accident in anthracite and metal mines may be ascribed to the fact that many of these mines work inclined veins where ventilation of breasts and stopes is not adequate to dilute readily the gases given off by explosives; also, in at least some cases large quantities of explosives must be used with proportionally heavy concentrations of poisonous gases. In most of the instances reports indicated that victims returned too soon after the blast.

TABLE 4. - Explosives accidents by causes

	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	Total
Bituminous-coal mines:												
Number of mines reporting	52	52	45	66	68	69	92	95	98	100	109	
a	12	5	2	6	7	-	8	5	4	2	2	53
b	2	2	-	3	1	2	3	4	1	-	7	25
c	-	1	2	1	-	2	-	-	1	3	2	12
d	-	-	-	-	-	2	2	3	-	2	2	11
e	6	8	3	6	3	10	12	8	8	9	8	81
f	1	-	-	-	2	-	-	-	-	-	-	3
g	-	-	2	-	-	-	-	1	-	2	-	5
h	-	-	-	-	-	-	-	-	-	-	-	-
n	-	-	-	-	-	-	-	2	3	3	3	11
Total	21	16	9	16	13	16	25	23	17	21	24	201
Anthracite mines:												
Number of mines reporting	7	26	23	22	29	27	21	26	33	27	37	
a	-	3	7	8	9	2	2	1	1	5	13	51
b	2	-	4	-	1	1	-	1	1	-	2	12
c	-	1	1	-	-	4	1	-	1	3	-	11
d	1	8	4	5	7	9	3	6	13	1	3	60
e	1	12	6	7	16	10	3	5	7	7	2	76
f	-	-	-	-	-	2	1	-	1	1	-	5
g	3	2	3	2	1	7	-	1	-	8	4	31
h	-	-	-	-	-	-	-	-	-	-	-	-
n	-	-	-	-	-	3	-	-	-	-	-	3
Total	7	26	25	22	34	38	10	14	24	25	24	249
Metal mines:												
Number of mines reporting	34	44	42	48	54	52	42	33	32	30		
a	4	2	9	5	2	1	4	9	-	2		38
b	3	5	-	3	2	3	1	-	1	1		19
c	2	2	-	-	-	-	1	-	-	-		5
d	8	1	4	5	-	-	-	1	-	-		19
e	6	12	10	3	-	2	1	-	5	5		44
f	-	1	-	-	1	-	-	-	1	-		3
g	-	-	-	-	-	-	-	-	-	-		-
h	-	-	-	-	-	-	-	-	-	-		-
n	2	12	-	-	7	-	-	1	-	-		22
Total	25	35	23	16	12	6	7	11	7	8		150

TABLE 4. - Explosives accidents by causes (Continued)

	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	Total
Quarry and open-cut mines:												
Number of mines reporting	103	118	132	129	141	166	173	148	151	157	146	
a	2	14	7	2	9	15	2	1	-	2	3	57
b	6	1	1	1	-	2	-	-	-	-	-	11
c	3	3	3	-	-	1	-	-	-	-	-	10
d	-	-	-	-	-	-	-	-	-	-	-	-
e	23	42	12	8	11	6	8	2	2	1	-	115
f	-	-	-	-	-	1	-	-	1	-	-	2
g	-	-	-	-	-	-	-	-	-	-	-	-
h	-	-	-	-	-	-	-	-	-	-	-	-
n	-	1	1	-	1	1	1	-	-	1	1	7
Total	34	61	24	11	21	26	11	3	3	4	4	202
Nonmetallic mines:												
Number of mines reporting	14	17	14	18	19	24	22	20	18	20	20	
a	2	3	-	2	-	-	-	-	-	-	1	8
b	1	-	-	1	-	-	1	-	-	-	-	3
c	-	-	-	-	-	-	-	1	-	-	-	1
d	-	1	-	-	-	-	-	-	-	-	-	1
e	-	1	-	-	-	-	-	-	-	-	-	1
f	-	-	-	-	-	-	-	-	-	-	-	-
g	-	-	-	-	-	-	-	-	-	-	-	-
h	-	-	-	-	-	-	-	-	-	-	-	-
n	-	2	-	-	1	-	-	-	-	-	-	3
Total	3	7	-	3	1	-	1	1	-	-	1	17

a = Premature shots.
b = Explosions of missed holes, or explosion of powder from missed hole, or removing powder from missed hole, or delayed shot.
c = While handling, storing, destroying, or transporting explosives or detonators.
d = Asphyxiation.
e = Flying material; includes powder burns when not otherwise classified, hit by blasted material.
f = Explosion of explosives or detonators outside the drill hole.
g = Explosion of gas or dust by blasting.
h = Fires caused by blasting.
n = Not otherwise classified.

All industrial high explosives when detonated are likely to produce toxic gases such as carbon monoxide, hydrogen sulphide, or oxides of nitrogen in varying amounts, depending on the class and grade of the explosive and the conditions under which it is stored and used. The increase in concentrated mining in coal mines often results in the use of larger quantities of explosives per day per working place and an urge to return to the working place promptly after the blast. Improved ventilation is required under these conditions and rules should prohibit return to the place after a blast until adequate time has elapsed.

Rounds of many holes, as in drifts, tunnels, raises, winzes, shafts, rock gangways, and stopes, usually have heavy charges per hole and produce large volumes of toxic gases. In such work types of explosives with low limit of toxic gases per pound of explosive should be used, the ventilation should be adequate, and men should be restrained from returning to the face too soon after the blast.

Misfired shots. - Accidents involving explosions of missed holes, explosion of powder from missed hole, removing powder from missed hole, or delayed shot were responsible for 70 (8.5 percent) of the explosives accidents reported. Twenty-five of these accidents occurred in bituminous-coal mines, 19 in metal mines, 12 in anthracite mines, 11 in quarries and open-cut mines, and 3 in nonmetallic mines.

Misfires can be prevented largely by the selection of proper explosives, by using the explosives before they are unduly aged, and by careful procedure in storing, priming, charging, and firing of the explosives.

Although by no means foolproof, electric shot-firing offers the best means of reducing the number of misfires. In electric firing misfires may result from conditions outside the borehole, such as poor method of storing resulting in damp or deteriorated explosives, open circuits, short circuits, too much resistance in firing lines, or not enough capacity at source of electric current, though, on the other hand, use of excessive current may precipitate explosions of gas or dust or both unless very carefully safeguarded.

In metal mining, rock-tunnel driving, and open-cut mining, a large number of holes are shot at approximately the same time, except that shots may be timed to go off at different intervals by the use of various lengths of fuse or delay electric detonators. Replacement of fuse by delay electric detonators by many companies has resulted in a marked reduction in the number of misfired holes.

How much time should elapse before return to a misfire has long been a much debated question. Although most State mining laws or company rules provide for a time interval before men may return to a misfire, there is great variation in the time limit specified. When electric detonators are used, at least 15 minutes should elapse before the men return to the face; this minimum should be increased greatly when conditions permit because of the possible hazards of loose roof or coal, or smoke dust and gases in the air if other holes have fired. Any misfire may prove to be a hangfire or a delayed blast, hence a reasonable time should elapse before return. One metal-mining company has established a rule that half an hour shall elapse from the time the last report is heard until return to the face, and when returning to the face it shall always be assumed that there is a missed hole in the face until it has been proved otherwise. A good rule is to leave a misfire alone for several hours before an attempt is made to handle it.

In coal mines the method of handling misfires prescribed by most State mining laws is that a new hole shall be drilled about 1 foot from and parallel to the misfired hole, charged lightly, and blasted in the usual manner. The object of the blast in the new hole is to expose the charge in the misfried hole so that it can be recovered; this method, however, has its own hazards, and the parallel hole should be drilled, loaded, and fired under most careful and experienced supervision.

In metal mining and tunneling, the common procedure in handling a misfire is to blow the tamping out with compressed air or wash it out with water under pressure, then insert a new primer, and fire. Removal of the tamping by water is much safer than by compressed air; and this method should be used when possible.

A misfire in a well-drill hole in a quarry or open-cut mine is a much more serious matter than a misfire in a coal or metal mine, and it should be handled only by a competent, experienced man. The usual method of handling a misfired well-drill hole is to remove the tamping from the hole and insert a new primer. In case of misfire in a deck-loaded well-drill hole, it probably will be necessary to remove both tamping and explosives down to the bottom charge.

Misfires should be handled only by competent persons and under the direction and immediate supervision of the foreman or assistant foreman. They should be handled preferably on the off shift and, until they are recovered, no persons should be allowed to work in or relatively close to the place where they are.

Handling, storing, destroying, and transporting explosives. - Accidents that occurred while explosives were handled, stored, destroyed, or transported resulted in 39 injuries in the five groups during the 11-year period. Bituminous-coal mining experienced 12, anthracite 11, quarries and open-cut mines 10, and metal mines 5 accidents of this type, while nonmetallic mines experienced 1. In general, the prevention of accidents at such times requires that each mine develop definite methods. Proper instruction of employees regarding the methods adopted and adequate supervision and discipline are highly essential; all of these phases have many ramifications that cannot be discussed in detail here.

Explosions of gas or dust by blasting. - Thirty-six injuries caused by explosions of gas or dust resulting from blasting were reported in anthracite and bituminous-coal mines. Anthracite mines, with 19 explosions, accounted for 31 of these injuries, and bituminous mines, with 5 explosions, for 5 injuries; black blasting powder and dynamite were responsible for all of the explosions.

The prevention of explosions of gas by explosives or any other cause requires adequate ventilation to dilute any gas liberated, proper testing for gas, and the use of permissible explosives in a permissible manner.

Explosions of coal dust can be prevented by the use of permissible explosives in a permissible way and by adequate rock-dusting and watering.

Explosion of explosives or detonators outside the drill hole. - Thirteen explosives accidents that resulted from explosions of explosives or detonators outside the drill hole were reported. Five of these were in anthracite mines, 3 in bituminous-coal mines, 3 in metal mines, and 2 in quarries and open-cut mines.

Accidents of this type usually result from carelessness or lack of systematic methods of handling explosives and detonators. They may result from (1) surplus explosives left after loading; (2) explosives pulled or blown from hole through lack of stemming and struck subsequently with pick or shovel; (3) rough handling; (4) use of improper tools for opening boxes of explosives or for crimping blasting caps; and (5) failure to require men to return unused explosives.

"Tramp" explosives or detonators are like poisonous snakes - they usually strike when least expected. More often than not, they badly maim or destroy the eyesight or other parts of the body of their victims. A check-up system requiring written reports of all explosives used, and return of unused explosives would prevent most accidents from this cause..

Nonclassified accidents. - Forty-six explosives accidents from miscellaneous causes were reported: 22 in metal mines, 11 in bituminous-coal mines, 7 in quarries and open-cut mines, and 3 each in anthracite and nonmetallic mines.

The definite causes of these 46 accidents are not known, since, under the accident-report classification, they were classed as "all others" and no details of the accidents were given; therefore, these accidents are not discussed.

Nature of Injuries From Explosives Accidents

Table 5 gives the nature of injuries caused by the explosives accidents reported by the five groups. Violence caused the greatest number of injuries in all of the groups. This result is to be expected, as the detonating action of explosives is naturally violent and any person in proximity to an explosion is very likely to be affected by violence. In quarries and open-cut mines, 90.6 percent of the explosives injuries were due to violence. Burn injuries were more frequent in bituminous-coal mines, while asphyxiations were more frequent in anthracite mines than in any of the other groups. In 52 of the reports the nature of the injury was not indicated.

TABLE 5. - Nature of injuries from explosives accidents

Group	Burns	Percent of total	Vio-lence	Percent of total	Asphyxi-ation	Percent of total	Not classi-fied	Percent of total	Total
Bituminous coal	51	25.37	127	63.19	11	5.47	12	5.97	201
Anthracite	29	11.65	157	63.04	59	23.70	4	1.61	249
Metal	2	1.33	107	71.33	19	12.67	22	14.67	150
Quarries and open-cut.	9	4.45	183	90.60	-	-	10	4.95	202
Nonmetallic	-	-	12	70.58	1	5.89	4	23.53	17
Total	91	11.11	586	71.55	90	10.99	52	6.35	819

SUMMARY

1. Participation in the National Safety Competition stimulates interest in accident prevention.
2. Marked progress in the prevention of accidents has been achieved, as indicated by an almost constant downward course in the accident-frequency rates for the contest group as a hole.
3. About 10 percent of all coal-mine accidents and 12 percent of all metal-mine accidents are caused by explosives.
4. The severity of explosives accidents is greater than that of most other types of accidents.
5. Quarries and open-cut mines reported the greatest number of fatal accidents due to explosives.
6. Metal mining had the highest rate in both frequency and severity of explosives accidents, while bituminous-coal mines had the lowest rate.
7. About 23 percent of the accidents reported involved two or more men.
8. Hit by blasted material is the greatest cause of injury from explosives accidents.
9. Asphyxiation from fumes of explosives was responsible for about 11 percent of all fatal and nonfatal explosives injuries.
10. Violence caused the greatest number of injuries in all the groups.

CONCLUSIONS

The hazards inherent in the use of explosives are generally well known and rules and practices have been devised to guard against them; yet, despite a fairly vigorous and continuous educational campaign waged by various agencies interested in the prevention of explosives accidents since about 1910, such accidents occur far too frequently. The more one knows about a particular hazard, the more respect he should have for that hazard; it would appear that there has been a failure to impress the users of explosives in the mining industry sufficiently with the seriousness of the hazards connected with the use of explosives.

The responsibility for preventing explosives accidents rests largely with the mine operator. It is his duty to select the proper and safe type of explosive for his particular purpose, to see that the explosives are safely handled, stored, and transported from the surface to the point of use; the operator should furnish adequate supervision and employ only competent men to handle explosives; and he should promulgate well-thought-out and plainly worded rules governing the handling and use of explosives and demand strict adherence thereto.

The individual worker who handles explosives also has a responsibility; it certainly is his duty to handle and use the explosives in accordance with company rules and State laws. The cause of most explosives accidents, like other types of accidents, can be traced to carelessness or misjudgment on someone's part, and very frequently the victim of the accident is responsible through his own negligence or foolhardiness.

Since human weakness is a large factor in the cause of explosives accidents, it would follow that the logical means of preventing these accidents would be to eliminate the human factor as much as possible. In other words, the fewer the men exposed to the hazards of explosives at an operation, the fewer the explosives accidents that will occur. Instead of having every miner carry his own explosives into the mine and prepare and fire his own shots, one man could do this for a number of miners and thereby greatly reduce the exposure to explosive hazards.

The preparation and firing of shots during the off shift, or when every one else but the "shooters" or "shot-firers" is out of the mine, is the safest of the ordinary ways of using explosives; the next safest method is to have shot-firers prepare and fire shots during the shift. Very few metal mines employ shot-firers; however, they are employed to a large extent in coal mines, and probably much of the better explosives accidents record of bituminous-coal mines is due to the greater use of qualified shot-firers in bituminous-coal mines than in other kinds of mines or mining.

In mechanized coal mining or in metal mining, where the operator furnishes the explosives, the employment of well-qualified shot-firers would not only be safer but also would be more economical and efficient.

The greater the exposure to explosives, the greater the number of explosives accidents that are likely to occur.